

# DVD flourishes despite format feuds

**DESPITE MANUFACTURERS' BICKERING OVER REWRITABLE DVD FORMATS AND THE LACK OF WIDESPREAD ACCEPTANCE OF A DVD-AUDIO SPEC, DVD TECHNOLOGY REMAINS ON A SURE COURSE TO SERVE IN APPLICATIONS FROM LIVING ROOMS TO SUPERCOMPUTERS.**



**D**EPENDING ON YOUR PERSPECTIVE, digital-versatile-disk (DVD) technologies may be cruising along or stranded as they wait for a standardized format or a killer application. Only a technology with the diversity of uses and possibilities of DVD could present a computer-system designer with such a mixed message. After all, DVD will presumably replace CD players, VCRs, CD-ROMs, computer

tape drives, optical disk drives, and who knows what else. Given the vast potential and ongoing arguments over formats, it's time to re-examine the state of affairs in the DVD world. DVD comprises technology that might solve problems in applications ranging from data acquisition to high-end video authoring. It's also one of those evolving technologies in which you must carefully decide when a DVD flavor is ripe for deployment.

DVD is taking over the desktop PC and consumer living room more quickly than almost any other technology, including

the CD, has been able to do. Still, it seems that DVD promised even speedier delivery of a greater number of functions. A debate among competing companies over rewritable DVD formats has slowed acceptance of DVD-RAM (rewritable DVD with random access) as a computer peripheral for backup, multimedia file storage, and other uses. Similarly, the consumer-electronics companies have wrestled with Digital Video Express (Divx) versus standard DVD-Video, and that debate most likely hurt sales of consumer DVD players over the 1998 holi-

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day season. Moreover, the DVD Forum ([www.dvdforum.com](http://www.dvdforum.com)) is still working on an audio format. An examination of each of the DVD technologies helps to pinpoint which DVD applications are now feasible and which you might expect to deploy later.

## MOVING PAST EARLY ADOPTERS

DVD-ROM drives for PCs and consumer DVD-Video players are currently the only two volume markets for DVD. However, the Divx controversy has hampered consumer-player sales (see sidebar "Divx slows DVD acceptance"). Despite the controversy, however, DVD-Video is a growing market and a technology that will clearly pervade society.

In the PC DVD-ROM arena, manufacturers have struggled to overcome a classic chicken-and-egg conundrum. Content producers haven't developed much DVD-specific content because of the lack of DVD-equipped PCs. You can play DVD-Video on DVD-equipped PCs, but manufacturers have shipped few interactive titles, such as games, that truly leverage DVD technology. On the other hand, PC vendors have been slow to widely deploy DVD until manufacturers ship new compelling content. In turn, DVD-drive vendors have been unable to ramp production volumes and lower drive prices.

The industry, however, reports good news on the DVD-ROM front. During the holiday season, most mid- to high-end PCs selling for \$1500 and more included a DVD-ROM drive in place of a CD-ROM drive. In fact, almost every DVD-ROM-drive vendor reports selling all the drives they could make as the holidays approached. Some even claim that they could have doubled sales if drive-manufacturing volumes had allowed.

## DVD-ROM TO HIT 70% OF NEW SYSTEMS

Content developers can start to take as a given the availability of DVD hardware among early adopters and even midrange customers. DVD-ROM-drive prices to PC OEMs have dropped to less than \$80, whereas CD-ROM drives still sell for more than \$30 to PC OEMs. By the end of 1999, most vendors expect 70 to 80% of new PCs to ship with DVD-ROM drives. Meanwhile, a DVD-equipped PC also must be able to decode MPEG-2 video and AC-3 audio (Reference 1 and

### AT A GLANCE

▷ More than 70% of all PCs will include digital-versatile-disk (DVD)-ROM drives by year's end.

▷ Software video decoders make PC DVD prices reasonable.

▷ DVD-RAM-drive sales are escalating despite some format disagreements.

▷ DVD-Audio acceptance must overcome the enhanced CD-Audio standard.

the DVD Forum's Web site provide more details on DVD). In the past, decoding DVD video required a relatively expensive add-in card. Now, however, new Pentium II and compatible  $\mu$ Ps can perform the decoding using host-based software or with the aid of new graphics ICs, mak-

newline.com) ships a DVD version of the movie *Lost In Space* with a computer-interactive game on the same disc. In another example, Digital Leisure ([www.digitalleisure.com](http://www.digitalleisure.com)) offers an interactive version of the arcade hit *Dragon's Lair* on DVD for around \$50. The DVD version enhances the arcade version by allowing players to use freeze frame and slow motion and to jump between scenes. Go to the local computer store, and you'll find a few additional titles; expect many more as the year goes on.

If you need to design a DVD-ROM into a system, you have plenty of drive choices. Vendors have ironed out most compatibility issues and are moving forward with faster drives. Any drive that claims to be "Multiread-compatible" should read DVD-Video discs as well as all CDs, including CD-ROM, CD-R (recordable), CD-RW (rewritable), and CD-Audio. The DVD-ROM-drive indus-



Able to read DVD-ROM and CD-ROM media at state-of-the-art speeds, the GF-1000 Series DVD-RAM drives from Hitachi come in internal and external packages and can store 2.6 Gbytes of data on each side of rewritable discs.

ing decoding technology almost free to consumers (see sidebar "DVD decoding moves from hardware to software").

You can also find some DVD titles on retailers' shelves. A number of titles, especially reference titles, leverage DVD capacity to ship on a DVD rather than on multiple CDs. Ironically, you may pay extra for the single-disc DVD version. Some new interactive titles also take advantage of DVD's inherent video capabilities. For example, New Line Cinema ([try probably would have been better off sticking with first-generation read speeds and reducing costs for the design. Instead, the 4 \$\times\$ , 8 \$\times\$ ...40 \$\times\$  marketing craze from the CD world has consumed the DVD-ROM industry as vendors try to one-up each other. Most of the newest drives on the market claim 4 \$\times\$  or faster speeds. For example, Hitachi in October announced the GD-2500, which offers 4 \$\times\$  speed and 5.52-Mbyte/sec read rates. The drive can read CDs at the equivalent](http://www.</a></p>
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of 24× CD-ROM speeds. Pioneer has even announced a 6× DVD-ROM drive. The leaders in the drive market include Pioneer, Panasonic, Sony, Toshiba, Hitachi, Philips, and AOpen (Acer).

#### REWITABLE SKIRMISH CONTINUES

For all the positives in the DVD-ROM arena, the major roadblocks of high prices and multiple competing formats stand in the way of widespread deployment of recordable and rewritable DVD formats. Rewritable DVD is compelling in a variety of computer applications just because of its potential storage capacity and reliable storage media. Moreover, recording digital video will prove to be one of the compelling applications that will make rewritable DVD a success. And real-time MPEG-2 encoding is closer than you might think (see sidebar "Rewritable DVD begs for video-encoding technology"). Unfortunately, the format wars have contributed to sparse acceptance and therefore high prices.



Panasonic's LF-D101 DVD-RAM drive reads not only all flavors of CD, but also DVD-ROM, DVD-R, and media from its own early rewritable phase-change PD drives.

## REWITABLE DVD BEGS FOR VIDEO-ENCODING TECHNOLOGY

Imagine taking the output from your camcorder, attaching it to your PC, digitally encoding the video data, and storing the video on a low-cost optical media with a shelf life and reliability head and shoulders above video tape. Rewritable digital versatile disks (DVDs) promise to make this scenario possible. Expect to see a camcorder with a built-in rewritable DVD within two to three years. But low-cost, real-time video-encoding products are now emerging that can serve early adopters in the home and in diverse embedded applications, such as medical imaging and vision systems.

Although it became clear over the past year that software-based MPEG-2 decoding was viable, most encoding designs still rely on relatively expensive hardware. Encoding schemes with less precision than MPEG-2 work in software, but consumers will demand MPEG-2-based encoding so that living-room

DVD players can display the stored video. This year, MPEG-2 encoding will remain primarily a hardware task, but the price is dropping significantly. Moreover, Intel ([www.intel.com](http://www.intel.com)) will roll out the Pentium III with the added Katmai instructions that promise to make software encoding viable.

For hardware-based video-encoding applications, C-Cube in November announced the DVxplore IC, which will cost as little as \$75 in PC-industry volumes. The IC targets both PC-DVD and consumer-digital-video applications that use the digital-video formats that digital camcorders use. Based on a MicroSPARC core with auxiliary DSP and motion-estimation engines, the IC can perform functions ranging from low-bit-rate MPEG-1 encoding for applications such as video e-mail to variable-bit-rate, DVD-quality MPEG-2 encoding. The IC also handles DVD decoding that's

perhaps unnecessary, given the move to software decoding. However, a hardware decoder does free host resources for other tasks. Typically, you can store one hour of DVD-quality video per gigabyte of storage space. A typical DVxplore implementation requires 8 Mbytes of memory along with the NTSC encoder and decoder, TV tuner, and other functions that state-of-the-art PC graphics cards, such as ATI Technologies' All In Wonder family, already include.

#### ENCODERS DEBUT

Meanwhile, at least two companies are demonstrating software-based encoders. Ligos Technology's GoMotion encoder for the Pentium III will emerge this year, but the company has demonstrated the software on a Pentium II. On a 400-MHz systems, the software can encode a half-resolution, 352x240-pixel, CCIR-601 video stream at 30 frames/sec. On a 266-MHz sys-

tem, the software encoder can handle 352x240-pixel Small Image Format streams. The company claims it will deliver full 720x480-pixel resolution on the Pentium III. Expect an OEM partner to bundle the software with a video card by midyear.

At Fall Comdex '98, ATI showed a software encoder from Quadrant International. Quadrant claims that its software running on a 450-MHz Pentium II can encode a full-resolution, 30-frame/sec CCIR-601 video stream. Moreover, with ATI's latest graphics IC that has both motion-estimation and inverse-discrete-cosine-transform engines onboard, the software can simultaneously encode a half-resolution CCIR-601 stream and decode a full-resolution CCIR-601 stream. ATI ships Quadrant's software decoder, so it's a safe bet that an ATI graphics card with the Quadrant encoding software will shortly emerge.



In addition to 4.7-Gbyte DVD-ROM, the DVD Forum specified 4.7-Gbyte DVD-R (DVD Recordable) and 2.6-Gbyte DVD-RAM formats. Like CD-R, DVD-R targets applications in both the computing and the consumer areas. The recordable format allows software authors to publish programs in relatively low quantities, whereas high-volume producers market DVD-ROM media. DVD-R could also allow a video producer to create low volumes of a disc—for example, an industrial-training video. DVD-RAM, meanwhile, targets the computer-peripheral market, offering random access with the ability to support more than 100,000 rewrite cycles. Pre-

sumably, DVD-RAM technology could also support the DVD-R-type application adding rewrite flexibility, assuming that DVD-RAM-drive and -media prices drop. After all, rewritable CD-RW drives that can also write CD-R discs are quickly supplanting CD-R drives.

## CROSS COMPATIBILITY KEYS ACCEPTANCE

In addition to prices falling into line, success for the above scenario depends on cross-format compatibility. Specifically, for DVD-R and DVD-RAM to succeed as authoring platforms, DVD-ROM drives and consumer DVD players must be able to read any disc that the recordable and rewritable drives produce. Early in re-

cordable and rewritable CDs, incompatibility with CD-ROM drives severely limited market acceptance of the CD-R and -RW products.

To ease compatibility issues, the DVD Forum specified the DVD-R format to store data similarly to the way DVD-ROM and -Video discs store data. As a result, DVD-ROM drives and DVD players should require only small firmware changes to read DVD-R discs. The recordable media exhibits lower reflectivity than stamped media, so the drives simply need to recognize the media type and adjust power to the laser to read DVD-R discs.

Ensuring compatibility with DVD-

## DVD DECODING MOVES FROM HARDWARE TO SOFTWARE

Just two years ago, it seemed far-fetched to think that software rather than hardware would take over the MPEG-2 decoding task. This year, however, almost all PC digital-versatile-disk (DVD) sales will rely on the host CPU to handle the lion's share if not all of the decoding. Some graphics chips and even a planned Cyrix  $\mu$ P have added motion-compensation functions and even inverse-discrete-cosine-transform (IDCT) blocks in hardware, and these additions allow lower end PCs to offer software-decoding capabilities.

There's little reason to rely on dedicated hardware for DVD decoding. If you plan to hook the output of your PC to a TV, you will get better quality from a hardware-based decoder, assuming that the decoder output connects directly to the TV. Most decoder boards, however, pipe the video into the graphics card, and you connect an output from the graphics card to the TV. In such a scenario, the hardware system offers no quality advantage. Only if your application requires simultaneous DVD decoding along with other computationally intensive tasks do you find a compelling need for a hardware decoder.

Many software DVD implementations still rely on some hardware assistance. ATI Technologies Inc pioneered the addition of a motion-compensation block in its graphics chips. With a software-only decoder, a DVD implementation needs a 350- or 400-MHz system to achieve video playback without degradation in frame rate or resolution. Microsoft ([www.microsoft.com](http://www.microsoft.com)) demands that a software decoder use less than 40% of the host CPU for the decoder to pass Windows Hardware Quality Lab (WHQL, often pronounced like "wickel"). Several decoders have been WHQL-certified on 400-MHz systems. With motion compensation in the graphics chip, a 266-MHz system can meet WHQL requirements.

You might think that escalating  $\mu$ P speeds eliminates the need for tricks such as motion compensation, but the concept is attracting a growing number of fans. Trident, Neomagic, S3, and Silicon Integrated Systems have all joined ATI by announcing graphics ICs with motion compensation. Moreover, Cyrix has announced the MX1 processor core with an integrated motion-compensation engine. ATI has gone one step further by adding

an IDCT engine to its latest Rage ICs for desktop and mobile applications. ATI claims that the IDCT function enables soft DVD even on 100-MHz Pentium-class systems. Whether using motion compensation or IDCT, the hardware assistance ensures flawless DVD playback without using CPU cycles that other applications may require. Moreover, the technology enables low-cost DVD in the retrofit and portable markets in which  $\mu$ P speeds typically lag behind those of desktop systems.

## TARGETING TOP OEMs

Zoran, Quadrant International, and Mediamatics currently dominate the DVD-software-decoding market. You can expect products to emerge from a number of smaller companies, including Cyberlink. Today, the market leaders do business only with the first-tier PC OEMs and some select graphics-board companies. As a result, unless you work for one of those top-tier OEMs, you can buy the decoders only bundled with systems or graphics boards.

However, expect the market to change over the next few years. The vendors have hesitated selling to end users for both

technical and logistic reasons. Decoder companies optimize their software for each OEM's application, taking advantage of such features as motion-compensation hardware. Eventually, the software will evolve to support most CPU/graphics-IC combinations, so that it wouldn't be a technical-support problem if it were sold to end users. Still, other logistic problems stand in the way. DVD decoders must carry Dolby licenses and DVD Forum ([www.dvdforum.com](http://www.dvdforum.com)) security licenses, and tracking such licenses could be an accounting nightmare. The decoder vendors will ultimately solve the problems, however, because they ultimately want to sell upgrades and even convert users from one decoder brand to another.

Quadrant and ATI won't stop with video decoding. The companies have also demonstrated software that can decode and display digital-TV broadcasts and even high-definition TV. For the cost of a PC with a premium graphics card and some software, you can be an early adopter of digital TV from cable or satellite sources. And the images look amazingly good on a crisp, 10-in. monitor.

RAM discs is more difficult. All CD and DVD media use spiraled tracks defined by so-called lands and grooves. The ROM media represents data with mechanically embossed pits stamped into grooves during manufacturing. All of the CD and DVD recordable and rewritable formats use a phase-change write scheme that changes the molecular structure of bit cells between amorphous and crystalline states. As in all CD media, lands define the tracks, and grooves in the DVD-ROM and DVD-R media store data. The DVD-RAM format specifies data storage on both lands and grooves. The DVD Forum chose to record on both lands and grooves because the scheme achieves an effective 0.74- $\mu$ m track pitch (the same as DVD-ROM), but the distance between lands or grooves is double that width. The wider tracks will presumably make the rewritable media cheaper. (See Hitachi's Web site for an excellent white paper on the DVD-RAM format.)

To read DVD-RAM media, a DVD-ROM drive or DVD-Video player must adjust to different reflectivity, read data on lands and grooves, and deal with a different recording format from that of a DVD-ROM. Inevitably, a rewritable format for random access must include technologies such as error checking and correction, noncontiguous data blocks, spare sectors, and other characteristics largely derived from hard disks. The debate continues about just how much it will cost DVD-ROM and -player manufacturers to add DVD-RAM read compatibility. This debate, whether or not it has merit, opened the door for additional rewritable formats, although supporters of the other formats may well have motives other than what's best for the industry.

Other rewritable formats that have emerged are DVD-RW, Multimedia Video Format (MMVF), and DVD+ReWritable (DVD+RW). Pioneer shepherded the DVD-RW format that closely mimics the format that CD-RW drives use. DVD-RW focuses on video-authoring applications. DVD-RW media supports only 1000 rewrites and lacks computer-peripheral necessities, such as defect management. The narrow focus of DVD-RW persuaded the DVD Forum to adopt the scheme as an additional rewritable standard. MMVF is NEC's (www.nec.com) proprietary scheme, but

the company has disclosed little about it other than its 5.2-Gbyte capacity.

## DVD+RW ESCHEWS DVD FORUM

The third rewritable format, DVD+RW, has the backing of drive developers Sony and Philips but also has the support of media, component, and shrink-wrapped-product vendors, including Hewlett-Packard (www.hp.com/storage), Mitsubishi Chemical (parent company of Verbatim, www.verbatim.ltd.uk), Ricoh (www.ricoh.com), and Yamaha (www.yamaha.com). The DVD+RW Compatibility Alliance (www.dvdrw.org) shepherds the DVD+RW standard. The format is a published European Computer Manufacturers Association (www.ecma.ch) standard and is under consideration

require only a firmware upgrade to read DVD-RW discs. The DVD-RW format has one other advantage: It can match the 4.7-Gbyte DVD-ROM capacity. It's the only choice of the rewritable formats that can store a full-length movie, which may be key to its professional-video target audience.

Still, questions linger about DVD-RW. A format with limited rewrites and applicability should result in a favorable trade-off elsewhere, such as in a lower price. Today, however, Pioneer offers \$5000, second-generation DVD-RW drives that can also write DVD-R discs. Meanwhile, you can buy DVD-RAM drives for less than \$1000. Pioneer claims that, in a year or two, the price for its third-generation drives will reach \$1000,



**With high-capacity rewritable-DVD technology coming soon, the battle is on to add MPEG-2 video-encoding capabilities into PCs, and C-Cube has delivered the sub-\$75 DVXplore IC targeted at the computationally intensive task.**

for acceptance as a standard by the International Standards Organization.

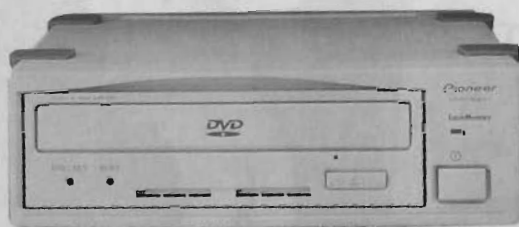
Pioneer has the most clearly defined market and can champion technology that backs that market focus. The DVD-RW format simply builds on the DVD-R format, of which only Pioneer has manufactured drives. Because of its target video market, Pioneer claims that compatibility with DVD players is an absolute must. Moreover, the company claims that any DVD player or DVD-ROM drive will

although that price might still be too high for many customers and certainly for any consumer acceptance down the road.

The DVD+RW camp is trying to straddle the fence between markets. The format includes an option for contiguous storage of video data, yet it also includes a more typical random-access option for computer applications. Sony claims that its DVD-ROM drives and players will be able to read DVD+RW media without changes. Most experts agree that it will be

easier to add DVD+RW read capabilities than DVD-RAM read capabilities to a product because DVD+RW still records data only in grooves. The DVD-RAM camp asserts that DVD-ROM drives and DVD players will typically need 300 to 500 extra gates in an ASIC to read DVD+RW discs and 2000 to 3000 gates to read DVD-RAM discs—a fairly insignificant difference in today's silicon arena.

In any case, it's hard to judge the claims of the DVD+RW camp. No one in that group has shipped drives, although Philips demonstrated a drive at Comdex Fall '98. At best, Philips claims it will ship a 3-Gbyte DVD+RW drive by midyear. But these companies have been promising drives for two years now, and the first drives may not arrive until year's end. Philips has also discussed a 4.7-Gbyte or larger second-generation drive, but the company indicates that such a drive will appear in the second half of 2000 at the earliest.



**With its DVR-S201 drive, Pioneer champions the 4.7-Gbyte DVD-RW format that's optimized for video-authoring applications rather than the random read/write capabilities that computer peripherals need.**

When you further examine the motives behind the DVD+RW camp, two items stand out. First, the gang of six supporting DVD+RW stands to lose the most if DVD-RAM or some other technology were to quickly supplant CD-RW. Although CD-RW took forever to gain market acceptance, the technology is finally selling well, and the DVD+RW supporters are the key suppliers of OEM CD-RW drives, retail drive bundles, and media. It won't bother them if rewritable DVD struggles for a few years. In a sec-

ond area of interest, Sony and Philips hold much of the intellectual property that's key to the CD and DVD-ROM markets from which they derive royalty revenue. Although Sony and Philips both participated in the definition of the DVD-RAM standard, the standard doesn't rely significantly on Sony or Philips patents. A broad group, including PC vendors, developed the DVD-RAM spec. The dissenting companies announced the DVD+RW initiative only after that development.

## DVD-RAM RAMPS, HIGHER CAPACITY COMING

You will have to wait to see whether DVD+RW can deliver on its promises, but DVD-RAM is approaching true volume shipments; Hitachi, Panasonic, and Toshiba are all shipping drives. The three shipped 150,000 drives last year and claim they will cumulatively ship 1.5 million drives this year and reach 6 million units in 2001. Prices have also begun to

## DIVX SLOWS DVD ACCEPTANCE

The Digital Video Express (Divx) initiative, championed by US retailer Circuit City and some movie studios, has surely hurt the consumer market for digital-versatile-disk (DVD) players. Divx-enabled players can play standard DVD-video titles along with Divx titles. Although DVD-video titles typically sell for \$15 to \$30, Divx titles typically sell for less than \$5. However, you can view Divx titles only on a single DVD player during a single 48-hour viewing period. After the initial viewing, you can buy additional viewings using a cable-pay-per-view-like scheme. You must permanently connect Divx players to a phone line, so that the Divx organization ([www.divx.com](http://www.divx.com)) can track titles and usage. The Divx site includes background on the format; meanwhile, a grassroots group, the National Organization to Ban Divx ([www.bandivx.com](http://www.bandivx.com)),

counters with its side of the story.

Like the Ban Divx group, consumers are largely rejecting Divx. Some decry the obvious invasion of privacy. The scheme can easily lead to huge unwarranted bills for consumers because the Divx organization can charge unwitting users who view—or whose children view—titles, even if they watch only a short segment. Moreover, most Divx titles lack the choice of wide-screen-letterbox and edited-for-TV formats that are typically stored on opposite sides of standard DVD-video discs. Some published and TV reports indicate that Divx had a banner holiday season. At the January '99 Consumer Electronics Show, however, the rumor mill was full of Divx horror stories ranging from deep discounts to increase sales and hefty sales incentives for retailers that push the technology.

Divx and DVD-video sales didn't meet the expectations of the consumer-electronics vendors last year, partially because of the Divx confusion. Some educated consumers are simply sitting on the sidelines, refusing to pay the price premium for Divx players but also refusing to buy any product until they are sure that publishers won't limit content to Divx releases. More important, a large part of the population simply doesn't understand the Divx concept, as the following anecdote demonstrates: Just before Christmas, I went to an auto shop to have my car repaired. The shop was just opening, and a half-dozen employees were discussing DVD. One of the employees had looked at DVD players the night before and was excited by the holiday-season promotion of five free Divx discs with a player purchase, although he

also decried the lack of titles from which to choose. I spent a half-hour trying to explain to this group that they could view those movies without additional fees only during one 48-hour period. They simply didn't believe me, although they certainly became even more confused and unlikely to make a DVD purchase.

You can argue that Divx is simply a consumer choice and that consumers can choose to buy standard DVD players and rent or buy titles in the VHS video-tape manner. Assuming that content providers always offer both standard DVD-video and Divx versions of each release, the choice does remain up to the consumer. Unfortunately, this is a consumer choice that has dramatically slowed market acceptance of a compelling new technology.



drop, and new, higher capacity products are on the way. You can buy DVD-RAM today for a retail price of \$799. One- and two-sided DVD-RAM discs store 2.6 Gbytes and 2.6 Gbytes/side, respectively, and cost \$24.95 and \$39.95. All three vendors vow to ship 4.7-Gbyte drives this year—perhaps beating first-generation DVD+RW products to market. And DVD-RAM vendors are planning drive enhancements. For example, Hitachi plans to prove that DVD-ROM drives can read DVD-RAM media. Expect such a DVD-ROM drive to debut by midyear. Hitachi also plans to add CD-R write capabilities to its DVD-RAM drive this year because consumers have access to the CD-R media, which sells for as little as \$1.

Installing and working with DVD-RAM drives is fairly easy if not seamless. The shipping products all use SCSI, and

vendors plan to add ATAPI in the future. Today, however, Windows 9x systems automatically recognize most SCSI host adapters. In a test of a Hitachi GF-1000 drive, it took less than 15 minutes to bring up a SCSI DVD-RAM drive as a replacement for an ATAPI CD-ROM drive. To write DVD-RAM media, however, requires additional software because Windows has no native support for the DVD-RAM format. The Format DVD and Write DVD software from Software Architects ([www.softarch.com](http://www.softarch.com)) comes with most DVD-RAM products. You can easily install the add-on software, although the DVD-RAM drive appears as two physically different drives in Windows Explorer—one CD-ROM or DVD-ROM drive and one rewritable removable-media drive.

Thus far, Hitachi, Toshiba, and Pana-

sonic are cooperating to promote DVD-RAM technology more than they are competing for business. All offer relatively similar products. (For a comparison of data rates, access speeds, and other characteristics, see **Reference 2.**)

While the DVD-RAM industry moves forward, the format disputes continue to slow market acceptance. And the DVD Forum has given up on forging a compromise between the DVD-RAM and DVD+RW camps. Assuming that the two and others, such as DVD-RW, will coexist, the Optical Storage Technology Association (OSTA, [www.osta.org](http://www.osta.org)) has stepped in to establish a baseline of read compatibility for DVD-ROM drives and DVD players. Previously, OSTA headed the Multiread effort in the CD market, and a Multiread drive reads all CD flavors.

## FOR MORE INFORMATION...

For more information on the digital-versatile-disk products and technologies discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use *EDN's* InfoAccess. When you contact any of the following manufacturers directly, please let them know you read about their products in *EDN*.

### AOpen America Inc

San Jose, CA  
1-408-922-2100  
[www.aopenamerica.com](http://www.aopenamerica.com)  
Circle No. 373

### ATI Technologies Inc

Thornhill, ON, Canada  
1-905-882-2600  
[www.atitech.com](http://www.atitech.com)  
Circle No. 374

### C-Cube Microsystems

Milpitas, CA  
1-408-490-6300  
[www.c-cube.com](http://www.c-cube.com)  
Circle No. 375

### Cyberlink Corp

Taipei Hsien, Taiwan  
011-886-2-86671-298  
[www.cyberlink.com.tw](http://www.cyberlink.com.tw)  
Circle No. 376

### Cyrix

Richardson, TX  
1-972-968-8388  
[www.cyrix.com](http://www.cyrix.com)  
Circle No. 377

### Hitachi America Ltd

Brisbane, CA  
1-650-589-8300  
[www.hitachi.com/storage](http://www.hitachi.com/storage)  
Circle No. 378

### Ligos Technology

San Francisco, CA  
1-415-437-6137  
[www.ligos.com](http://www.ligos.com)  
Circle No. 379

### Mediamatics

Fremont, CA  
1-510-668-4850  
[www.mediamatics.com](http://www.mediamatics.com)  
Circle No. 380

### Neomagic Corp

Santa Clara, CA  
1-408-988-7020  
[www.neomagic.com](http://www.neomagic.com)  
Circle No. 381

### Panasonic Industrial Corp

Milpitas, CA  
1-408-945-5600  
[www.panasonic.com](http://www.panasonic.com)  
Circle No. 382

### Philips Optical Storage

San Jose, CA  
1-408-570-5677  
[www.os.philips.com](http://www.os.philips.com)  
Circle No. 383

### Pioneer

Long Beach, CA  
1-310-952-2111  
[www.pioneerusa.com](http://www.pioneerusa.com)  
Circle No. 384

### Quadrant International

Malvern, PA  
1-610-251-9999  
[www.qi.com](http://www.qi.com)  
Circle No. 385

### S3 Inc

Santa Clara, CA  
1-408-588-8000  
[www.s3.com](http://www.s3.com)  
Circle No. 386

### Silicon Integrated Systems

Taipei, Taiwan  
011-02-29161619-353  
[www.sis.com.tw](http://www.sis.com.tw)  
Circle No. 387

### Sony Electronics

San Jose, CA  
1-800-352-7669  
[www.sony.com](http://www.sony.com)  
Circle No. 388

### Toshiba America Information Systems Inc

Irvine, CA  
1-949-455-2000  
[www.toshiba.com](http://www.toshiba.com)  
Circle No. 389

### Trident Microsystems Inc

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Both consumers and the OEMs that sell to consumers set the market requirement that a CD-ROM drive be able to read all flavors. But OSTA defined the technical challenges and helped develop the silicon infrastructure to build such drives. Now, OSTA hopes to do the same for DVD. Rumor has it that Philips, Sony, and Hewlett-Packard largely led the move to establish the as-yet-unnamed DVD OSTA effort. The DVD+RW camps believe that the OSTA effort will prove that adding DVD-RAM read compatibility to DVD-ROM drives and players is simply too costly and that the consumer would ultimately have to pay a hefty premium for a Multiread drive. The DVD+RW camp may also hope the OSTA effort further delays acceptance of DVD-RAM technology. If the DVD-RAM camp can in the meantime deliver DVD-ROM drives that can read DVD-RAM media, the DVD-Multiread issue could become insignificant, with DVD-RAM becoming the de facto standard rewritable format.

You might think that the lengthy effort

that established standards for distributing DVD-Video movies on DVD-ROM media might have also covered potential audio applications. Unfortunately, the future of DVD-based audio is no clearer now than the vision in the rewritable DVD crystal ball. There's no question that DVD holds great appeal as an audio medium. The capacity provides options such as storing more music. Imagine every recording from your favorite artists on one disc. Alternatively, the DVD capacity enables digital-audio encoding with even greater audio precision or the storage of more tracks that fully take advantage of Dolby Surround Sound, Digital Dolby, or other multichannel audio schemes.

Several factors have conspired to delay a fully accepted DVD-Audio standard. For starters, standards definition is fraught with roadblocks as companies lobby for adoption of their own intellectual property. Adopting a company's ideas gives the company a head start in developing products and yields royalty revenue from other vendors that design

compatible products. In the case of DVD audio, the sheer magnitude of options for using 4.7 Gbytes of storage has further delayed the process. Ultimately, however, the legacy of CD-Audio may delay acceptance of DVD-Audio.

The DVD-Audio spec is working its way through the DVD Forum and is currently at Revision 0.9. The next step to Revision 1.0 would mean that the Forum would release a spec, but, as DVD-Video proved, widespread acceptance could take months or even years. DVD-Audio will likely offer options for how audio is recorded, although all will rely on PCM recording as CD players do today. Authors will get a choice of 48- to 192-kHz sampling rates and 16-, 20-, and 24-bit quantization bit depths.

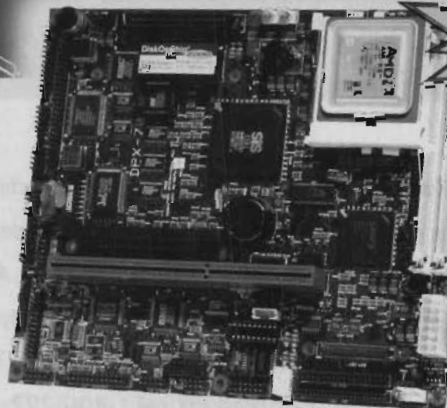
Authors could store more than 700 minutes of music on the proposed DVD-Audio disc if they use CD quality. Alternatively, they could use the spec-defined Meridian Lossless Packing (MLP), a new lossless compression scheme. The proposed format combines MLP with 24-bit quantization and 96-kHz sampling to de-

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liver 74 minutes (CD length) of high-quality audio, including support for 5.1 channels. Perhaps, the lossless encoding will satisfy the audiophiles that decry CD-Audio quality, although few consumers seem disappointed with CD-Audio quality. Meridian Audio Ltd ([www.meridian-audio.com](http://www.meridian-audio.com)) developed MLP for professional-audio applications, and Dolby Labs ([www.dolby.com](http://www.dolby.com)) licenses the technology and will likely control DVD-Audio licensing.

DVD-Audio has only one apparent shortcoming: Although DVD-Audio players can play conventional CDs, conventional CD players can't play new DVD-Audio titles. Also, the music industry despises media transitions. This realization has led Sony and Philips to once again rebel in the face of DVD standards and offer what they call Super Audio CD (SACD). SACD would rely on a two-layer disc. Conventional CD players would recognize only the first layer that carries a standard

CD recording. The second, higher capacity layer would carry a higher quality version for SACD players. SACD would replace PCM with *direct-stream digital* (DSD) recording; which operates with a 2.8224-MHz sampling rate. Presumably, you can easily downconvert the new sampling rate to CD, Minidisk, and digital audio-tape formats.

SACD, however, doesn't offer the flexibility of DVD-Audio. The SACD format can essentially match the capability of DVD-Audio in storing 74 minutes of multichannel audio with far greater than CD quality. But, SACD doesn't let authors trade off recording length versus precision and number of channels. Sony and Philips may win some early converts because authors can sell SACDs in place of conventional CDs. It's likely, however, that consumers will ultimately prefer the flexibility of DVD-Audio that Panasonic and Thomson Consumer Electronics (manufacturers of RCA, [www.rca.com](http://www.rca.com), and Proscan

brands) are currently championing.

As you can see, the potential for DVD is perhaps greater than any storage technology in the history of the computer and consumer-electronics industries. And DVD will ultimately see widespread adoption and a long life span. After all, movie studios don't move to a new medium very often. Beware the growing pains, however, before you commit to a specific DVD course for your design. □

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